Estimation of emittance growth due to a lignment error of an injector cavity

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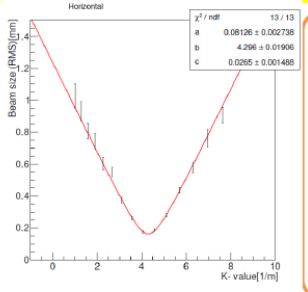
Motivation

- As measuring in the injector beam line, the emittance growth is observed in a injector SC cavities by a factor of 2.

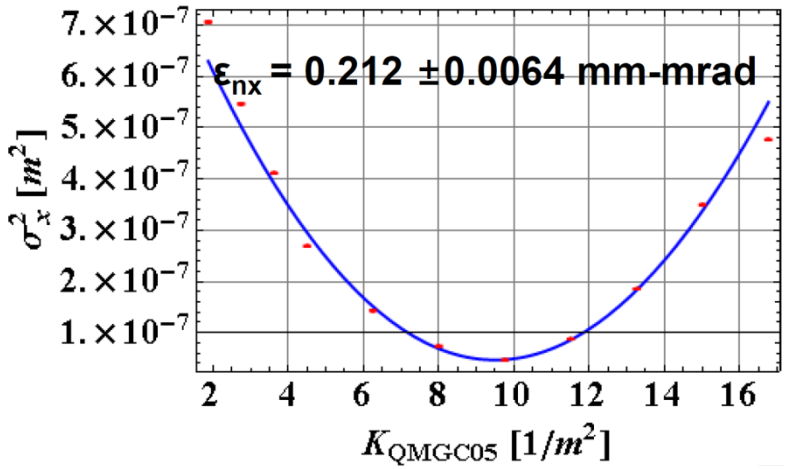
電子銃下流でのエミッタンス(390 keV)
Solenoid-scan法で測定
規格化エミッタンス: 0.1 mm mrad



カソードの初期エミッタンス
カソード材質 : GaAs
kT = 120 meV
d = 0.8 mm

$$\varepsilon_n = \frac{d}{4}\sqrt{\frac{kT}{mc^2}}$$

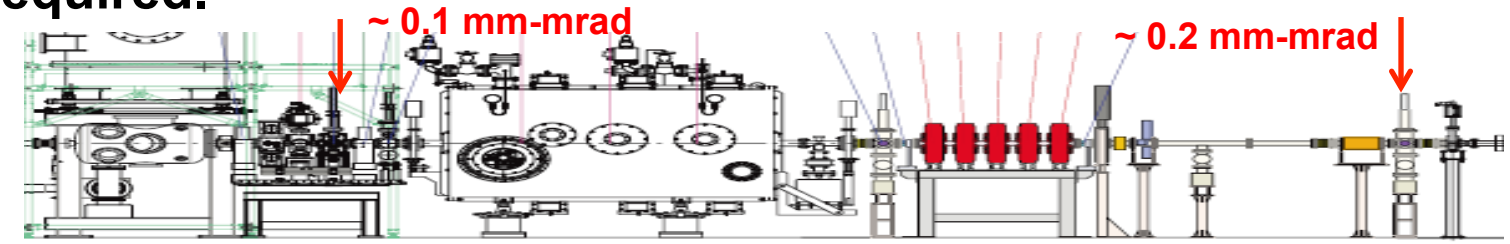
$$= 0.097 \text{ mm mrad}$$



- カソードによって決まる初期エミッタンスと同程度であることが確認された

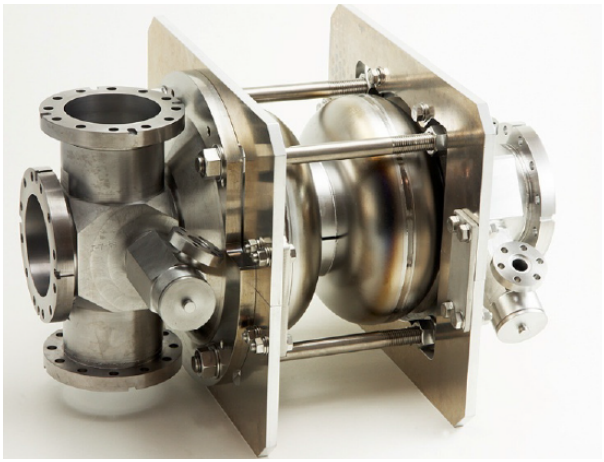
⇒輸送路でのエミッタンス増大は極めて小さい

- In order to explain the growth of the emittance in this section, th e study for estimation of effect of alignment errors of cavities is required.

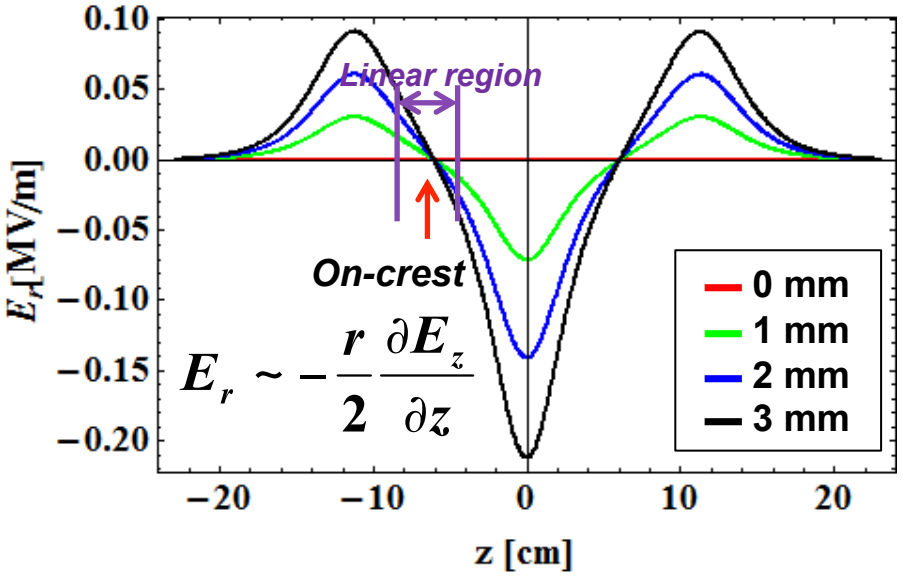


Possible source of emittance growth

- The transverse force provided by the cavity imparts a transverse momentum on the bunch which varies i n time over the passage of the bunch.

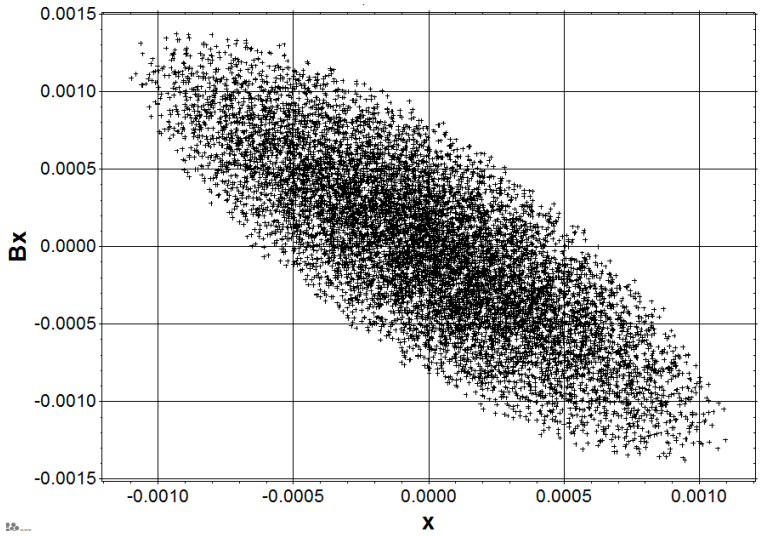


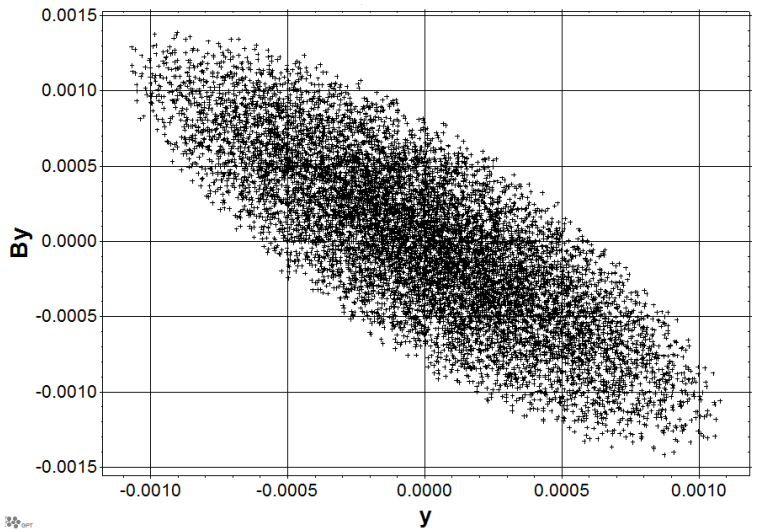
2 cell injector cavity

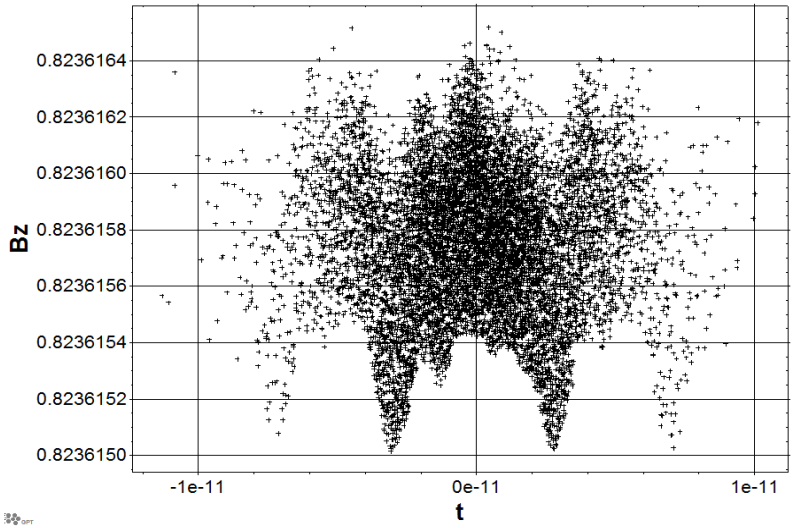


- It can cause the growth of projected emittance.

Beam parameters at the entrance of SRF cavity







Beam parameters

ε_{nx} = 0.0968 mm-mrad

ε_{ny} = 0.0968 mm-mrad

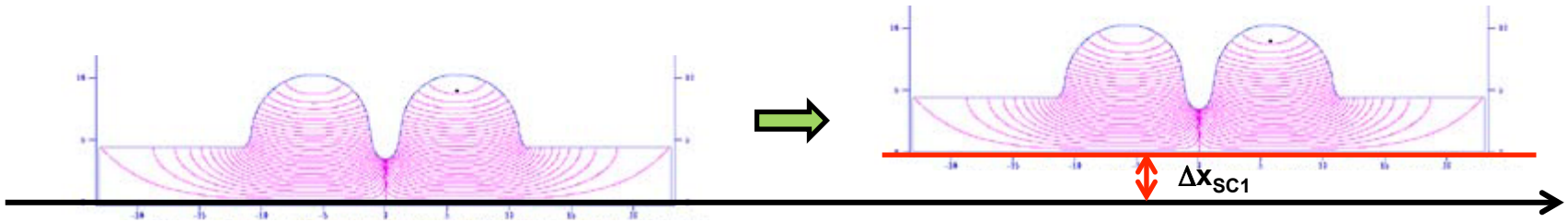
ε_{nz} = 2.775 eV-ps

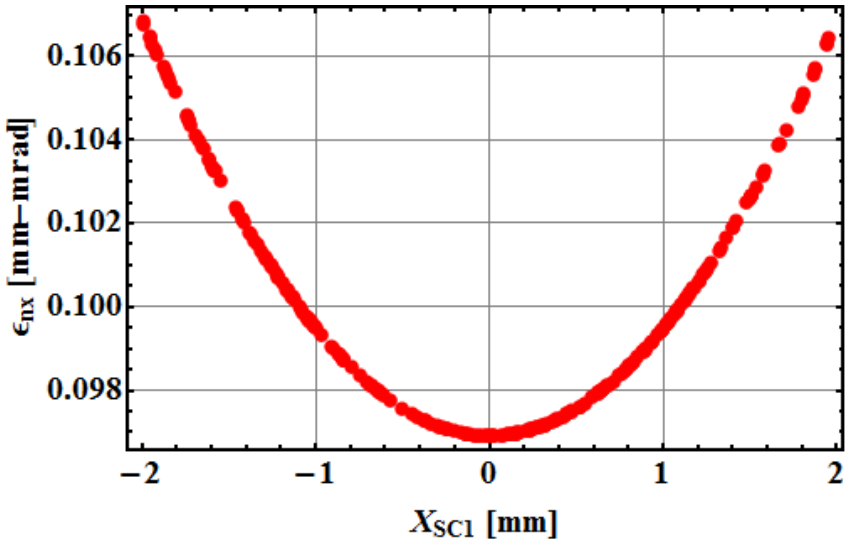
β_x = 1.14 m, α_x = 2.077

β_x = 1.14 m, α_x = 2.076

$\Delta E/E$ = 0.000237 %

Displacement of a cavity



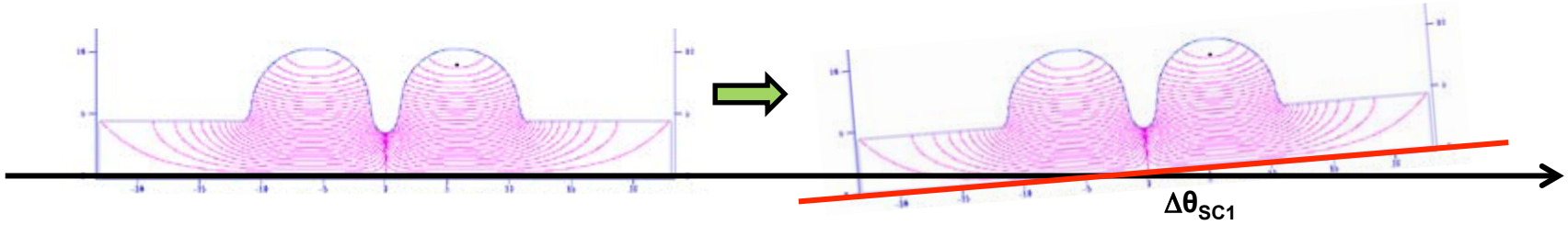


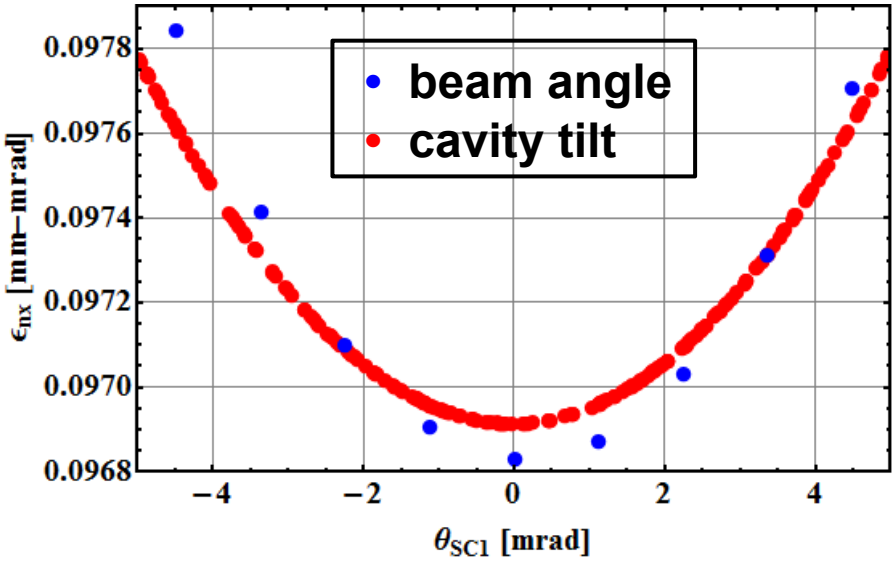
When the alignment error of ±2 mm was given to a cavity, the emittance growth is

$\Delta\varepsilon_{nx}$ **~ 0.0102 mm-mrad.**

It's correspond to 10.5 %.

Tilt of a cavity and beam angle





When the tilt error of ±5.0 mrad was given to a cavity, the emittance growth is

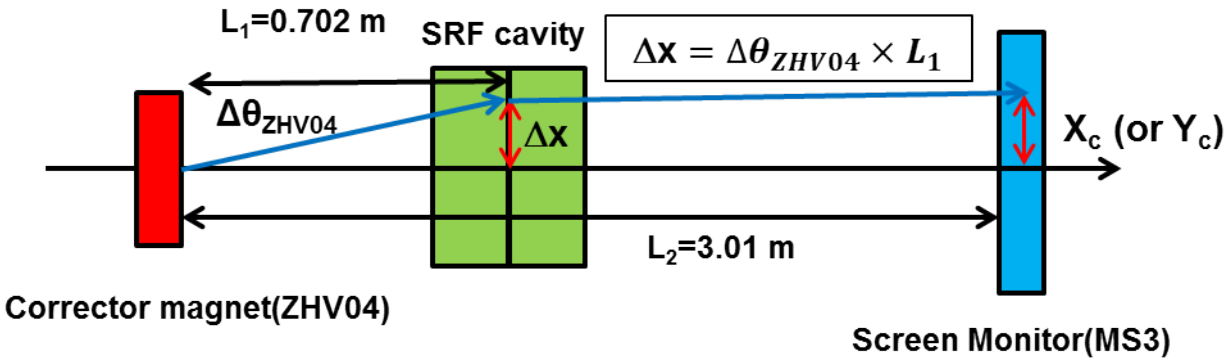
$\Delta\varepsilon_{nx}$ ~ 0.001 mm-mrad.

It's correspond to 1.03 %.

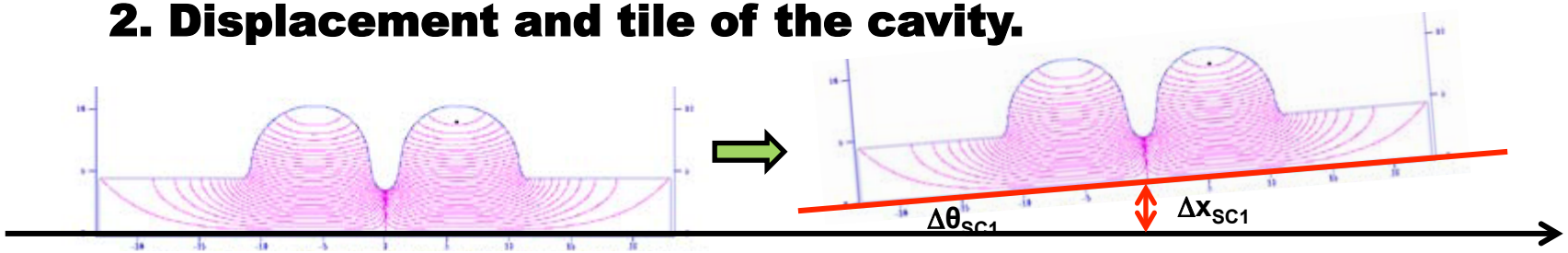
Alignment error of cavities with beam angle

There has two kind of errors in the simulation.

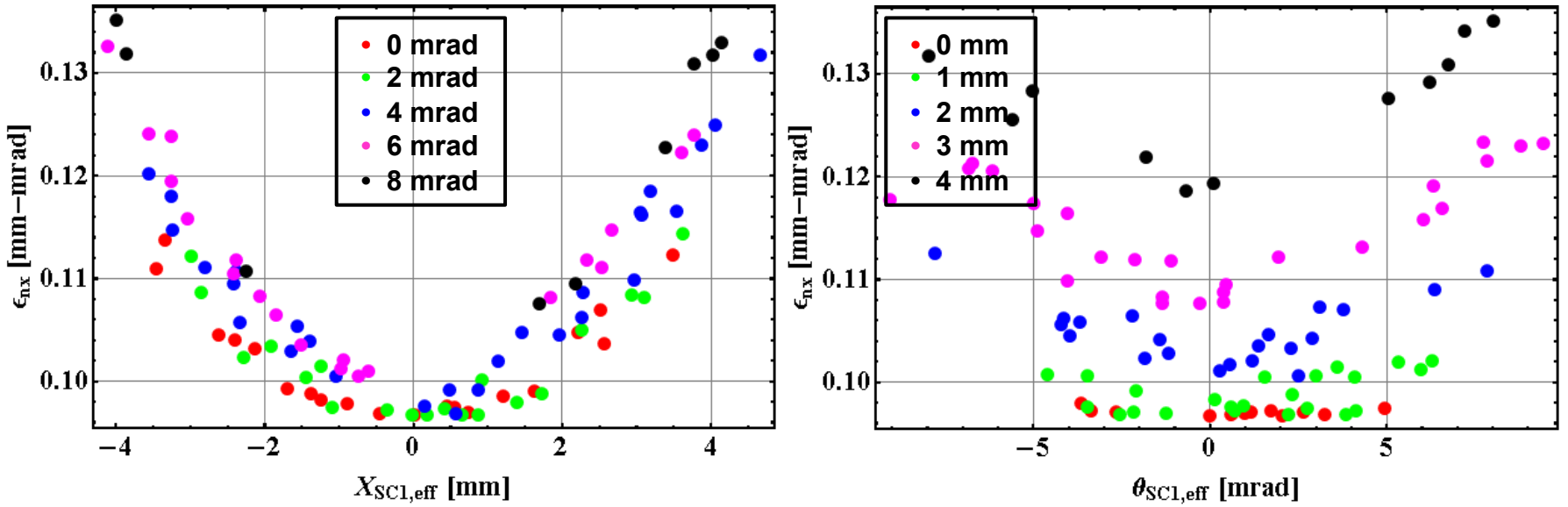
1. Beam orbit and angle (given by the corrector magnet).



2. Displacement and tile of the cavity.



Alignment error of cavities with beam angle



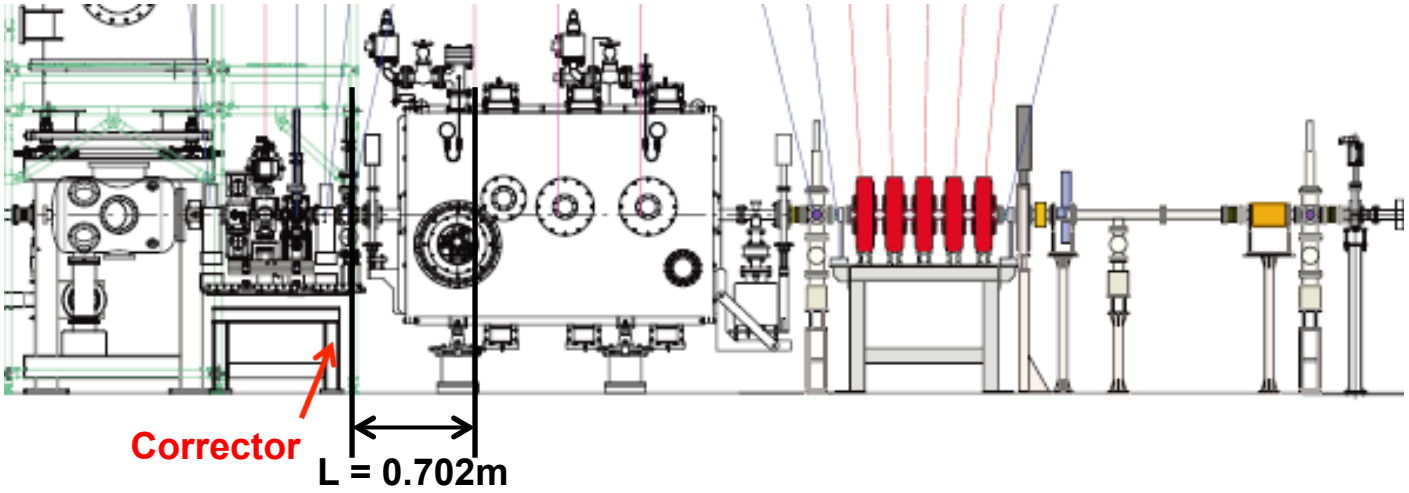
The effective beam offset was defined by

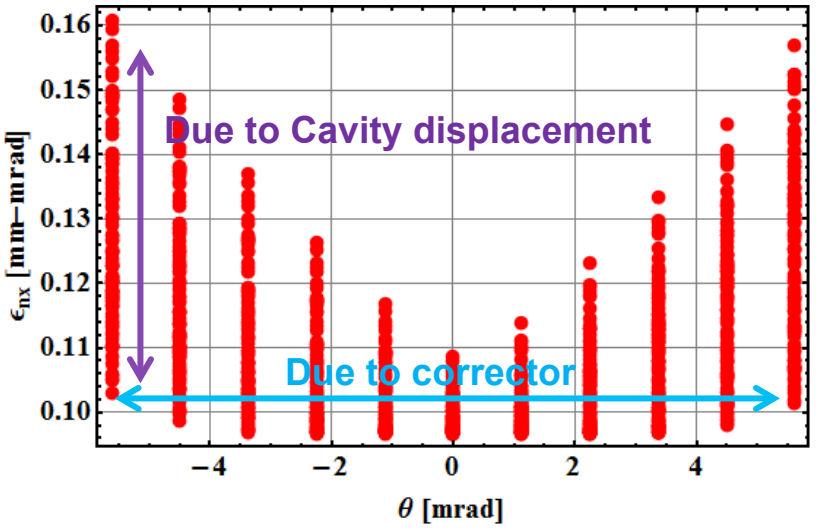
$$\Delta X_{SC1,eff} = \Delta X_{SC1} - \Delta X_{beam}$$

The effective beam angle was defined by

$$\Delta \theta_{SC1,eff} = \Delta \theta_{SC1} + \Delta \theta_{beam}$$

Alignment error of cavities with beam angle



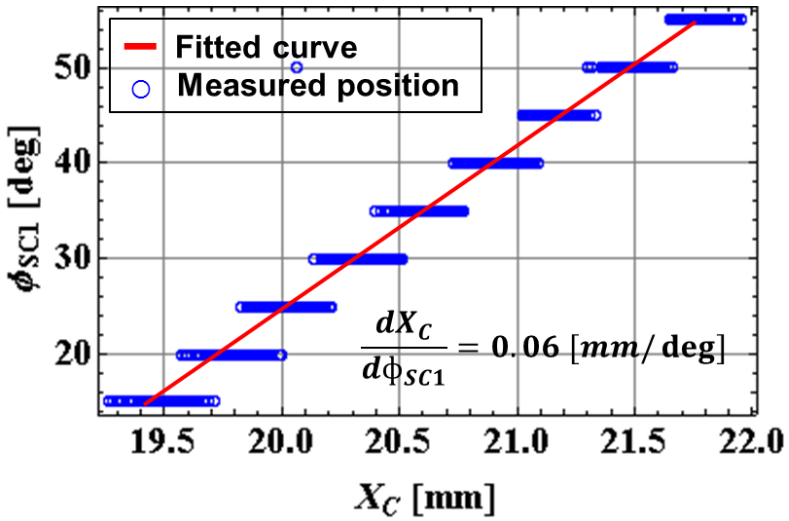


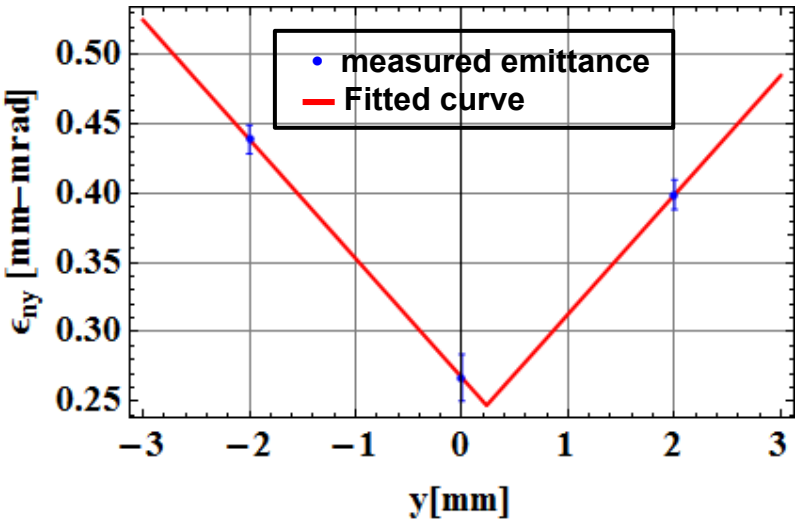
When the displacement of the central orbit with beam angle was given by one corrector is installed just before a cavities, the growth of the emittance is strongly depend on the alignment error and angle.

$\Delta\theta_{corr} = \pm 5.61$ mrad

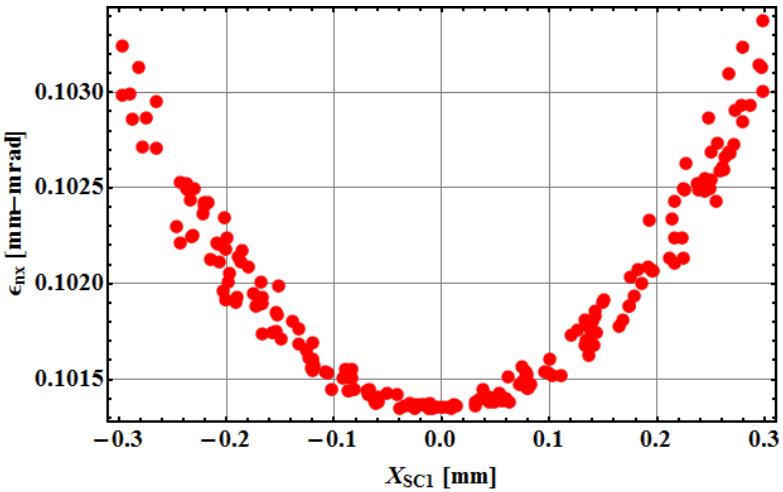
Summary

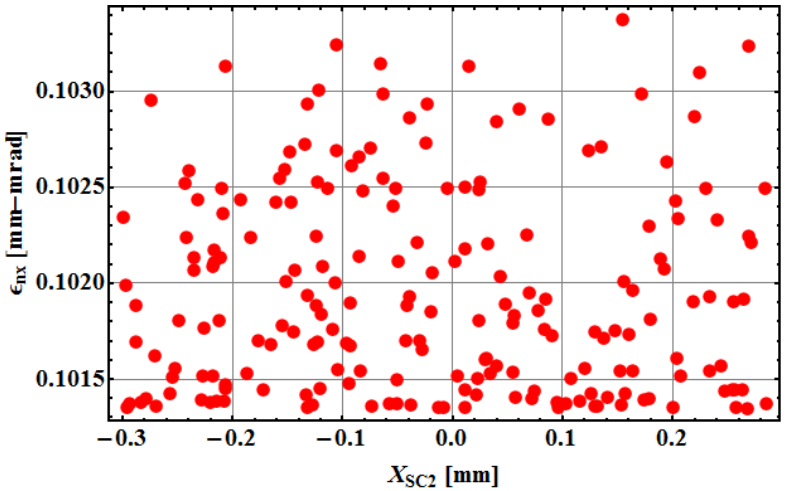
- The effect of the tilt of the cavity, beam offset and beam angle w as studied using GPT code.
- The beam offset in the cavity is mainly determined the growth r ate of the emittance.
- In the experiment, the beam offset inside the injector cavity was well corrected. Therefore, the growth of the emittance in this s ection was not explained by the effect of the error of the cavity.

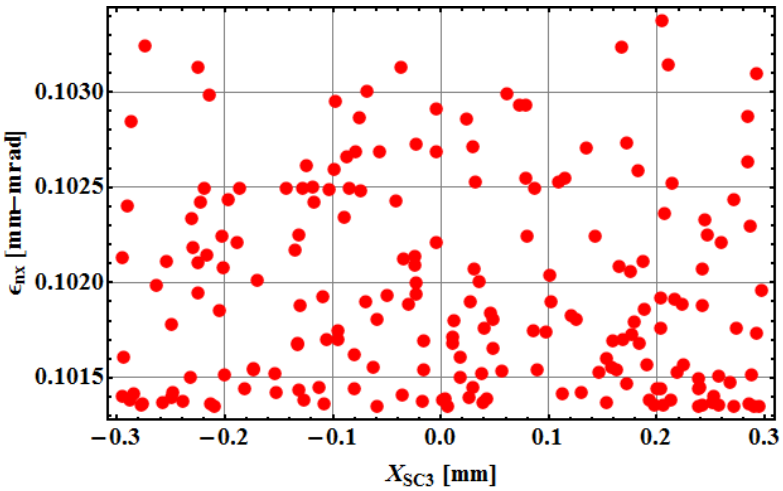




Alignment error of cavities







The uniform distributed alignment erro r was given for three cavities.

$\Delta x = \pm 0.300$ mm

When only alignment error of three cav ities was given, the growth of the emitt ance is strongly depend on the alignm ent error of 1st cavity.